DOCUMENT RESUME

ED 292 768 SP 029 989

AUTHOR Spragg, Carolyn; Noble, Larry
TITLE A Comparison of Selected Kinematic Factors in Male Baseball and Female Fast Pitch Softball Batting.
PUB DATE 87
NOTE 26p.
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Athletes; *Baseball; *Biomechanics; Comparative Analysis; Higher Education; *Psychomotor Skills; *Sex Differences; *Softball; Womens Athletics

ABSTRACT

Six female intercollegiate varsity softball players and six male intercollegiate varsity baseball players were filmed from overhead while batting a wiffle ball off a batting tee at hip height. Movements of the hips, trunk, upper body segments, and bat were analyzed. Group comparisons indicated that males had higher peak linear and, angular velocities for all body segments measured, except for hip angular velocity. Males reached peak segmental velocities in a sequence proceeding from proximal to distally adjacent segments. Females' peak segmental velocities did not follow this sequence. Bat kinematics followed similar patterns and magnitudes. The results of this investigation suggest that both body size and technique may account for the faster bat velocities of males. (Author/JD)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED292768

"A Comparison of Selected Kinematic Factors in Male Baseball and Female Fast Pitch Softball Batting."

by
Carolyn Spragg and Larry Noble
Kansas State University

*Larry Noble is with the Department of Physical Education and Leisure Studies at Kansas State University, Manhattan, Kansas, 66506. Carolyn Spragg is at 102 Snug Harbor Way, Earleville, Maryland, 21919. Direct all Correspondance to Larry Noble.

SP 029 989

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

L Noble

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

BEST COPY AVAILABLE

ABSTRACT

"A Comparison of Selected Kinematic Factors in Male Baseball and Female Fast Pitch Softball Batting."

Six female intercollegiate varsity softball players and six male intercollegiate varsity baseball players were filmed from overhead while batting a wiffle ball off of a batting tee at hip height. Movements of the hips, trunk, upper body segments, and bat were analyzed. Group comparisons indicated that males had higher peak linear and angular velocities for all body segments measured, except for hip angular velocity. Males reached peak segmental velocities in a sequence proceeding from proximal to distally adjacent segemnts. Females peak segmental velocities did not follow this sequence. Males' hips, trunk and left arm peak velocities occurred at mean times of 0.096 s, .077 s and 0.073 s prior to ball contact (PC). The females' sequence was left arm (.097 s PC), hip (.074 s PC) and trunk (.071 s PC). Mean male bat maximum linear velocity at the center of percussion was substantially faster than for females (male V = 38.420 $\pm$ 1.545 ms^{-1}; female V = 32.570 $\pm$ 2.478 ms^{-1}). Bat kinematics followed similar patterns and magnitudes as reported in other references. The results of this investigation suggest that both body size and technique may account for the faster bat velocities of males.

Researchers investigating batting have predominantly studied male baseball batters, and the extent to which these results apply to female fast pitch softball hitting is questionable. A dedicated fast pitch softball coach or batter has very little information available to assist her and must examine the research done with male baseball batters and hope that the results will apply to females. There are several problems inherent in assuming that male baseball batting and female softball batting are comparable. Although the game objectives are the same and the tasks are similar, they are far from identical. The pitcher in baseball is 60 feet 6 inches away from the batter, while in softball that distance is only 46 feet; yet the pitchers in both sports deliver the ball at similar speeds (Hay, 1978). Thus, the softball pitcher gets the ball to the plate in less time than the baseball pitcher, giving the softball batter less time to watch the pitched ball and complete her swing than the baseball batter. Even more important to this investigation are the physical and mechanical differences between males and females which may affect the swing. For example, hip width, location of total body center of gravity, proportionate mass of body segments, and upper body strength are potentially significant differences between the two groups relative to batting.

For these reasons, research of the mechanics of males batting baseballs cannot validly be applied to the female softball batter without modification. The extent to which these factors apply to female batters needs to be determined. In addition, direct comparisons between males and females within the

same investigation is needed to control for procedural variability. The degree of difference between the performances and the mechanics of male and female batters has not been explored.

The purpose of this investigation was to compare selected kinematic factors in male and female batters hitting a wiffle ball off of a batting tee using their customary bat and swing pattern. Specific variables selected for comparison were hip and trunk rotation, linear and angular velocities and accelerations of the upper body segments and bat, and the timing sequence of maximum velocities acheived by each segment and the bat center of percussion relative to bat-ball impact.

Methods and Procedures

Six female intercollegiate varsity fast pitch softball players and six male intercollegiate varsity baseball players were selected and volunteered for this study. All subjects were right handed batters and were judged by their coaches to be consistent, effective hitters. This judgement was based on a subjective rating, batting average, and slugging percentage (total bases ÷ times at bat). Mean heights for female and male subjects were 165.52 and 180.13 cm, respectively. Respective mean weights were 602.11 and 774.20 nt for females and males.

Observation Procedures

Subjects were filmed from overhead at 100 FPS with a LOCAM 16 mm camera mounted 3.7 m feet above the bat level during the swing. A mirror placed along the side of the hitting platform in the camera's field of view and tilted $\pi/4$ rad relative to the horizontal plane allowed the camera to see the front foot strike at the end of the stride. The following joint centers were marked prior to test sessions so they could accurately be determined from an overhead view: (1) shoulder joint, (2) elbow joint, (3) wrist joint, (4) first metacarpal joint of the third finger of the left hand, and (5) third metacarpal joint of the third finger of the right hand. Subjects also wore two nylon belts - one around the pelvic girdle, and the other around the thorax - to determine more accurately determine the position of the respective segment. The pelvic girdle belt had a "V" shaped projection which protruded posteriorly in a horizontal plane. The thoracic belt had a projection which protruded posteriorly. When viewed from above with the subject in the anatomic position, the thoracic projectile bisected the pelvic girdle projectiles. A board 1 m in length was place horizontally in the center of the area of bat movement during the swing at the level of the ball for use as a multiplier. Figure 1 shows an overhead view of the experimental setup. The belts were modified from Atwater (1970). Ground reaction forces of the front foot were also measured during each swing; however, these data are not included in this study.

The center of mass and center of percussion of each bat were determined using procedures described by Noble (1985) and marked with black masking tape.

The subjects' task was to stand on a raised batting platform and to take ten trials hitting a wiffle ball in a line drive off of a batting tee, using their normal swing pattern. All subjects hit right handed using a parallel stance and provided their own bats.

The female subjects used two bats; five used a black aluminum bat, and one female used a white aluminum bat. The males also brought two aluminum bats, one white and one black. All bats were weighed, and balanced on a knife edge to determine the center of mass, which was marked with a ring of contrasting (black or white) tape. The location of the center of mass was recorded as the distance in centimeters from the impact reaction axis. The impact reaction axis was located under the first finger of the right hand. Male impact reaction axis was assumed to be 16.8 cm from the knob end (Noble, 1985), and the female reaction axis was measured by the experimentor (17.5 cm). The swing axis was measured between the hands on the bat (Eggeman and Noble, 1985), and was 4.8 cm from the reaciton axis for males and 4.4 cm from the reaction axis females. Both axes were measured from the knob end of the bat.

The center of percussion (q) of the bat was determined by swinging the bat as a pendulum at the reaction axis and timing the period (T) of the swing. Distance from the axis to the center of percussion was then $(24.83877)T^2$ (Noble, 1985). The moment of

inertia (I) was calculated by the formula $(24.83877)T^2mr$; m is mass in kilograms and r is distance in centimeters from the center of mass to the reaction axis. The parallel axis theorem was then used to calculate moment of inertia relative to the swing axis. Radium of gyration (K) was calcualted from the moment of inertia of the swing axis, from the formula $I = mK^2$. This system for bat measurement was described by Noble and Eck (1986). The results of these measurements are presented in Table 1. The center of percussion was marked with a ring of contrasting tape prior to filming.

After bat and subject preparations were finished, the tee was adjusted and practice swings were taken until the hitter felt comfortable. The batter was told to attempt to hit the ball hard and straight up the middle of the field. An experimentor and the subject independently rated each hit on a scale from 1 to 10. For each trial, the subject stood on the raised batting platform and looked toward an assistant holding a ball in the normal pitcher's location. The batter assumed a parallel stance in accordance with a taped line on the middle of the batters box and force platform. The batter signalled her/his readiness and the film and force platform recordings began. The assistant then dropped the ball held in his extended right hand. The batter watched the assistant, and began the swing when the ball was released. Ten trials were conducted for each subject and the three top-rated trials were selected for detailed analysis.

Data Reduction and Analysis

Each image of each selected swing was projected onto a Grafpen digitizing surface (47 cm x 47 cm) and the location of selected landmarks and joint centers entered into a digital mini computer. Velocities and accelerations were calculated using the finite difference method. Calculated data were then smoothed using a Butterworth second order dual low-pass digital filter with a frequency cutoff of 15 hz. The following kinematic variables were selected for analysis.

1) peak linear velocity and acceleration of bat center of percussion (COP) and center of mass (COM);
2) peak bat angular velocity and acceleration;
3) peak angular velocity and displacement of the hips and trunk;
4) peak linear velocity of left arm, left forearm, and left hand;
5) time of occurrence relative to impact of each peak velocity and acceleration;
6) left elbow position at impact.

The mean value of the three selected trials for each subject was the criterion measure for all variables.

Results

Table 1 contains group means, standard deviations and mean differences for all peak magnitudes. There were only small group differences on peak hip angular velocity (AV) and total hip angular displacement (ang dis); however, these values for the trunk were substantially greater in males. Also, the peak linear

velocities of the center of mass of the left arm, left forearm, and left hand were greater in males than females.

Comparison of the position of the left elbow at impact indicated that the females' elbow was in a more extended position than that of the males. (.26 rad deviation from straight vs. .55 rad)

Peak linear bat velocities and accelerations (LA) of the COP and COM were both studied to facilitate meaningful comparisons with other studies. The angular velocity and acceleration (AA) of the bat were also calculated. All of the bat peak kinematic parameters were greater in males. Patterns for male and female means for bat linear velocity, linear acceleration, angular velocity, and angular acceleration for the duration of the swing are given in Figures 2-5. The patterns are very similar for males and females with the males having higher peak values in all cases. Females began their linear acceleration approximately 0.030 s sooner than the males and reached their peak angular acceleration 0.010 s earlier.

Timing of Kinematic Peaks Relative to Impact

Although comparisons of the magnitudes of selected kinematic values are important, examination of the time of occurance of these peak values may provide even greater insight. Thus, the time prior to ball contact (time PC) was recorded for each peak kinematic variable, and group means were calculated for each variable's time PC. In addition, the mean total swing time for each group was compared. Total swing time was defined as the

time from the initial movement of the bat toward the ball to impact of the bat and ball. Table 3 provides summary data on both groups for these variables. The males' mean swing time was .041 s shorter than the females' mean swing time. This was expected in light of the slower bat linear velocities of the female subjects.

Differences beyond overall duration in the timing pattern between males and females were found. The sequence in which different body segments reached their respective peak velocities also differed between male and female subjects. Males reached peak hip AV at an average of .096 s PC and peak trunk AV at the mean time of .076 s, roughly .020 s later, while females reached their peak hip AV and peak trunk AV almost simultaneously. Females' peak hip AV occurred at an average of .076 s PC, which is .020 s later in the swing than male peak hip AV. Female peak trunk AV occurred at a mean time of .071 s PC, (.055 s closer to contact than for males). Notable differences were found between the time PC of the left arm segment peak linear velocity for males and females. The left arm peak LV mean time PC was .073 s for males, and .097 s for females. Thus, the males' peak segmental velocities occurred in a sequence consistent with descriptions of the mature skilled throwing movement. More massive and proximal segments reached peak velocity first, followed by the most adjacent distally located segment. The females' hip, trunk, and left arm sequence was different from the males' sequence and this sequential pattern, with average values of .074 s, .071 s, and .097 s PC, respectively.

Males and females were similar in the mean time of peak left

forearm LV (.064 s and .064 s PC, respectively), peak left hand LV (.054 s and > .057 s PC), peak bat COP LV (.010 s PC for all subjects) and peak bat COP LA (.031 s and .031 s PC, respectively). The only other notable group difference occurred in the bat angular data. While peak bat AA occurred at .010 s PC for all subjects, peak bat AV occurred earlier in the swing for females (.044 s PC) than for males (.025 s PC).

Discussion

It is important to note that the female swing was not merely a slower version of the male swing, but involved a different pattern than that of the males. It is hypothesized that the females have proportionately larger hips than males and a larger hip moment of inertia, and therefore greater resistance to hip rotation. If this were true, then the females would need more time than males to generate the same peak hip AV. Females would then not have enough time remaining in the swing after reaching peak hip AV to complete the same sequence of segmental peak velocities as the males. The females in this study seemed to have solved the problem by beginning their left arm early. Every female in each trial analyzed reached maximum linear velocity of the left arm before hip and trunk maximum angular velocity - yet the females' forearm, hand and bat velocities peaked at times identical to the males. Thus, the crucial difference between male and female swings was the timing of peak velocities for the left arm and hips.

While is possible that the females initiated arm movement

early to compensate for the late-peaking hips, another hypothesis is that females may have difficulty holding the left arm back due to interference from the breasts. Hip rotation causes chest rotation, which may force the left arm forward prematurely. In either case, the premature peaking of left arm linear velocity by females may fail to take full advantage of momentum created by peak hip and trunk angular velocity.

Overall, females in this study had slower bat speeds than males. However, the range of individual peak bat linear and angular means for subjects in each group overlapped. Individual female bat COP peak LV means ranged from 29.899 to 36.454 ms^{-1}. Subject means for males' bat COP peak LV ranged from 35.839 to 40.267 ms^{-1}. Individual means for bat peak AV overlapped as well, with the females ranging from 30.486 to 40.044 rs^{-1}, and the males ranging from 39.702 to 46.771 rs^{-1}.

The only significant timing difference between male and female bat kinematics occurred in the angular acceleration of the bat. Females reached mean peak bat max AA .019 s before males, indicating that females may extend their elbows earlier in the swing than males. Left elbow position was measured in the frame of film immediately before and after ball contact. All subjects had fully extended elbows immediately after impact, but the females' left elbow was extended an average of .299 rad further than males in the frame before contact. Thus, males straightened the elbow more than females in the last .010 s before impact. Early straightening of the left elbow by females may be related to the early initiation of left arm linear velocity.

The results of this investigation are generally comparable to those of other batting studies. McIntyre and Pfautsch (1982) found similar magnitudes and timing of peak linear velocities of males' upper extremity segments. Several studies have investigated maximum resultant bat linear velocity, but comparison between studies is dependent upon the point of the bat used to measure linear velocity. Their results, along with the results of this investigation, are summarized in Table 4.

The mechanics of college male baseball batters in this study are similar to those described in the other investigations in Table 4. Messier and Owen (1984) analyzed females, and their results are comparable to the females in this investigation. The use of a batting tee to eliminate pitching differences does not seem to have significantly affected these characteristics of the swing. Without time and accuracy limitations imposed by pitched balls, females consistently needed more time to swing the bat, with less resultant linear bat velocity than males. Females also took longer to reach peak hip angular velocity and reached left arm maximum linear velocity earlier than males. This suggests that the shorter pitching distance (and resultant time constraints) may not be the only factor limiting female bat speed.

Bat velocity peaked an average of 20 ms prior to contact for both males and females and was actually decreasing at impact. These results support the conclusion of Messier and Owen (1985) that the striking implement rarely reaches maximum linear velocity at impact in skilled performances.

The results of this investigation suggest that technique may

contribute to the relatively slow bat speeds of females. Group differences may be due to the differences in body size between males and females. The female batter may need to initiate hip rotation earlier in the swing, and hold the left arm back so that the left arm linear velocity peaks after hip angular velocity. An open batting stance may assist the female batter in achieving earlier hip rotation. Although each subject was consistent across trials, the high within-group variability of the female subjects compared to the male subjects indicates that the skilled males were more homogeneous than the skilled females. The female subjects may have been less skilled than the males; as invariance is a well-known characteristic of highly skilled performance. Females may not have had as many opportunities to play organized ball as the males did.

Further research is clearly indicated for female softball batting. An increased number of subjects would allow the researcher to compensate statistically for the higher within-group variability. The interrelationship between hip, trunk and left arm motion parameters and ground reaction forces needs to be studied further to provide insight regarding the effective technique for female softball batting.

This study used a simplified hitting task so that the ability to detect differences in movement pattern could be improved. However, because this method did not impose the differential demands on the batters that game-like hitting conditions do, further studies involving comparison of hitting techniques during these circumstances would be beneficial.

References

Atwater, A. E. (1970). Movement characteristics of the overarm throw. Unpublished doctoral dissertation, University of Wisconsin, Madison, WS.

Eggeman, G.W. and Noble, L. (1985). Design and testing of a baseball-bat transducer. Experimental Techniques, 9:2, 20-23.

Hay, J. G. (1978). The Biomechanics of Sports Techniques, 2nd ed. Englewood Cliffs, NJ: Prentice-Hall.

McIntyre, D. R. and Pfautsch, E. E. (1982). A kinematic analysis of the baseball batting swings involved in opposite-field and same-field hitting. Research Quarterly for Exercise and Sport, 53, 206-213.

Messier, S. P. and Owen, M. G. (1984). Bat dynamics of female fast pitch softball batters. Research Quarterly for Exercise and Sport, 55:2, 141-145.

Messier, S. P. and Owen, M. G. (1985). The mechanics of batting: analysis of ground reaction forces and selected lower extremity kinematics. Research Quarterly for Exercise and Sport, 56:2, 138-143.

Noble, L. (1985). Empirical determination of the center of percussion axis of softball and baseball bats. In D. A. Winter (Ed.), Biomechanics IX-B, International Series on Biomechanics, , Vol. 5B, (pp 516-520).

Noble, L. and Eck, J. (1986). Effects of selected softball bat loading strategies on impact reaction impulse. Medecine and Science in Sport and Exercise, 18, 50-59.

Table 1

Bat Specifications

Variable	Softball Bats: Black	Softball Bats: White	Baseball Bats: Black	Baseball Bats: White
Period of swing (s)	1.459	1.440	1.476	1.473
Mass (kg)	.768	.978	.903	.858
Location of impact reaction axis *	32.8	32.5	33.8	39.8
Location of swing axis *	37.2	36.9	38.6	44.6
Location of center of percussion *	52.9	51.5	54.1	53.9
Moment of inertia, reaction axis ($cm\ kg^2$)	1331.5	1638.2	1652.3	1839.6
Moment of inertia, swing axis ($cm\ kg^2$)	1567.9	1936.9	1999.9	2187.2
Location of radius of gyration *	45.2	44.5	47.1	50.5

*All locations are in centimeters from the knob end of the bat.

Table 2.

Group Comparisons of Peak Kinematic Parameters.

VARIABLE MEASURED	FEMALE MEAN	FEMALE S.D.	MALE MEAN	MALE S.D.	Mean Difference (M - F)
Peak Hip AV (rs^{-1})	22.702	1.625	25.309	3.699	2.607
Hip Ang Dis (rad)	3.139	.355	3.195	.425	.056
Peak Trunk AV (rs^{-1})	12.332	1.925	17.329	2.803	4.997
Trunk Ang Dis (rad)	1.692	.227	1.963	.142	.271
L. Arm Peak LV (ms^{-1})	2.941	.412	3.687	.405	.746
L. Forearm Peak LV (ms^{-1})	5.342	.811	7.087	.761	1.745
L. Hand Peak LV (ms^{-1})	7.735	1.013	9.8325	1.087	2.098
L. Elbow Pos Imp* (rad)	.254	.125	.553	.097	.299
Bat COM Peak LV (ms^{-1})	17.494	1.046	22.182	1.155	4.688
Bat COM Peak LA (ms^{-2})	685.787	132.780	981.923	101.130	296.136
Bat COP Peak LV (ms^{-1})	32.568	2.478	38.424	1.545	5.856
Bat COP Peak LA (ms^{-2})	685.787	132.780	981.923	101.130	296.136
Bat Peak AV (rs^{-1})	35.540	4.110	43.885	2.580	8.345
Bat Peak AA (rs^{-2})	307.270	22.074	458.775	58.150	151.501

*The position of the elbow at impact value represents the acute angle from a fully extended elbow position (0 rad is straight).

Table 3.

Time of Occurrance of Peak Kinematic Values
Relative to Ball Contact.

TIME OF VARIABLE*	FEMALE MEAN	FEMALE S.D.	MALE MEAN	MALE S.D.	Mean Difference (M - F)
Swing Time	.228	.018	.187	.020	-.041
Peak Hip AV	.074	.016	.096	.012	.022
Peak Trunk AV	.071	.019	.076	.012	.055
L. Arm Peak LV	.097	.015	.073	.005	-.024
L. Forearm Peak LV	.064	.012	.064	.008	0
L. Hand Peak LV	.057	.014	.054	.005	-.003
Bat COP Peak LV	.010	0	.010	0	0
Bat COP Peak LA	.031	.002	.031	.003	0
Bat Peak AV	.010	0	.010	0	0
Bat Peak AA	.044	.015	.025	.004	-.019

* All variables measured in seconds prior to ball contact (PC)

Table 4.

Comparison of Peak Resultant Bat Linear Velocities.

SOURCE	SEX OF SUBJECTS	PEAK RESULTANT BAT LV AT:*		
		BAT COM	BAT COP	BAT TIP
Spragg (1986)	Male	20-23*	35-40	
Shapiro (1979)**	Male	26-34		
McIntyre and Pfautsch (1982)	Male			39-42
Spragg (1986)	Female	16-18	29-36	
Messier and Owen (1984)**	Female	19***		

* All values reported in meters per second.

** Used three dimensional resultant linear velocity.

*** Inferred from the study's methodology and discussion that researchers used COM.

Figure Captions

Figure 1. Overhead View of Experimental Set Up
Legend:
1. Raised batting platform
2. Side view mirror
3. Top of subject's head
4. Bat COM
5. Bat COP
6. Trunk projectile
7. Hip projectiles
8. Left shoulder jt.
9. Right shoulder jt.
10. Right elbow
11. Right wrist
12. Left wrist
13. Ball on batting tee
14. Force platform

Figure 2. Bat Linear Velocity

Figure 3. Bat Angular Velocity

Figure 4. Bat Linear Acceleration

Figure 5. Bat Angular Acceleration

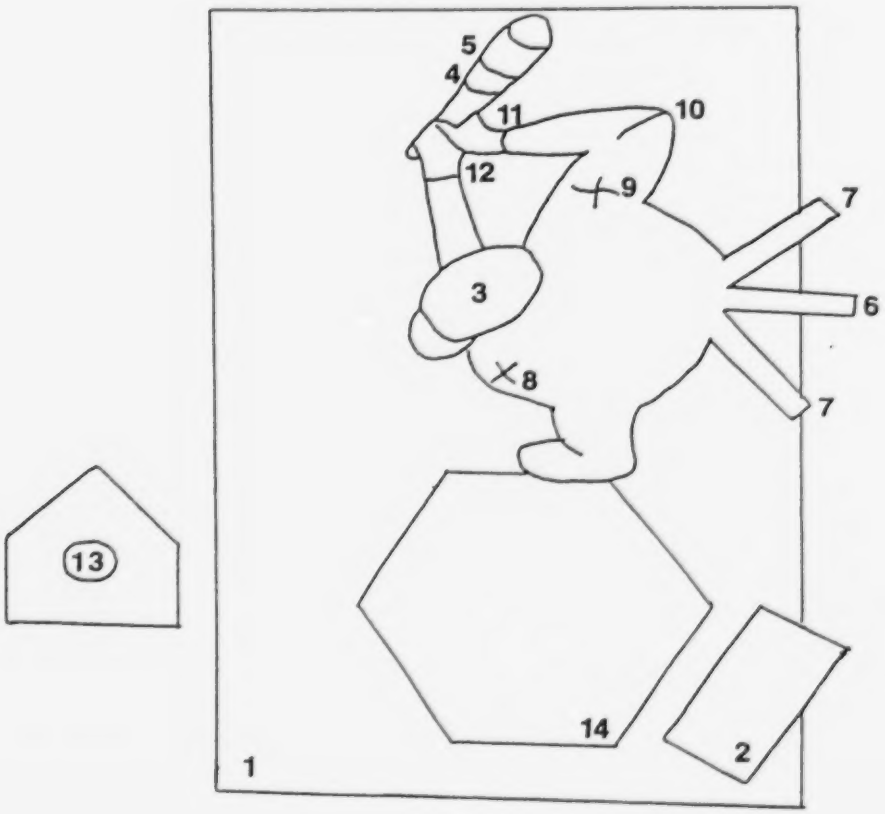

Figure 1. Overhead View of Experimental Set Up

Legend:

1. Raised batting platform
2. Side view mirror
3. Top of subject's head
4. Bat COM
5. Bat COP
6. Trunk projectile
7. Hip projectiles
8. Left shoulder jt.
9. Right shoulder jt.
10. Right elbow
11. Right wrist
12. Left wrist
13. Ball on batting tee
14. Force platform

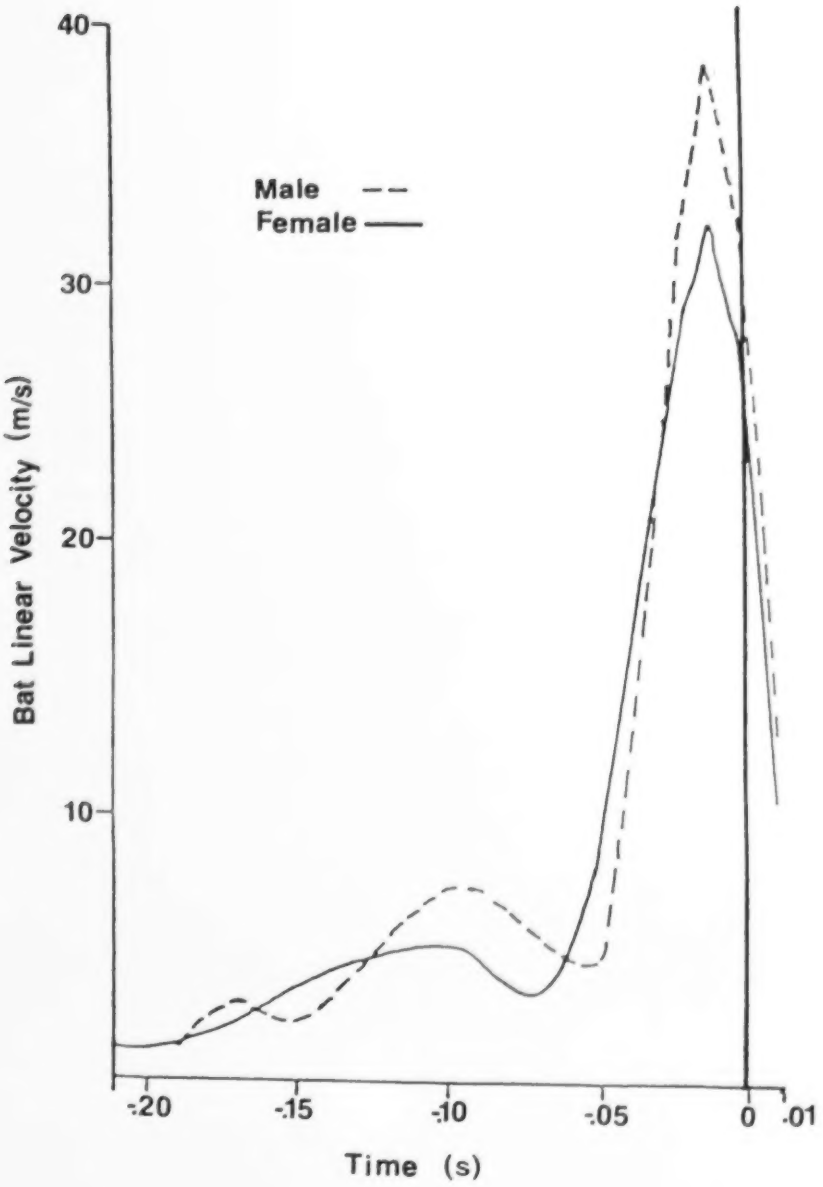

Figure 2. Bat Linear Velocity

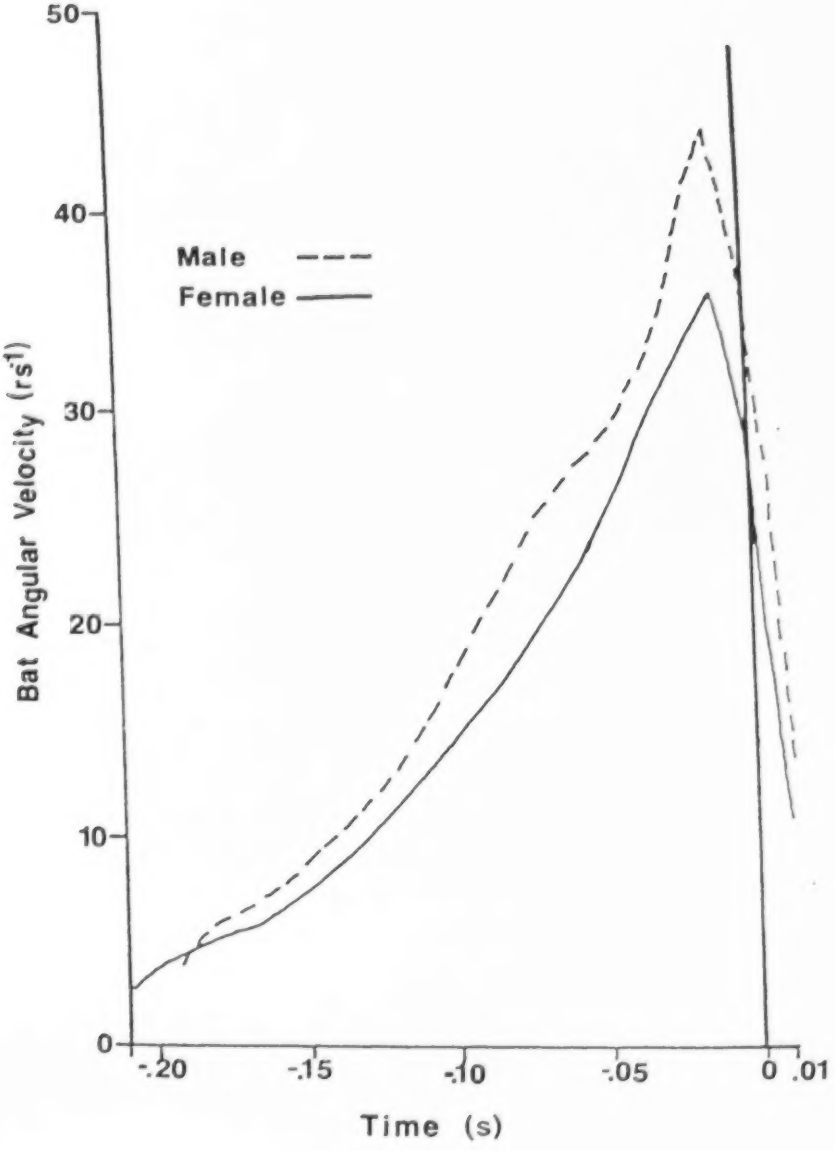

Figure 3. Bat Angular Velocity

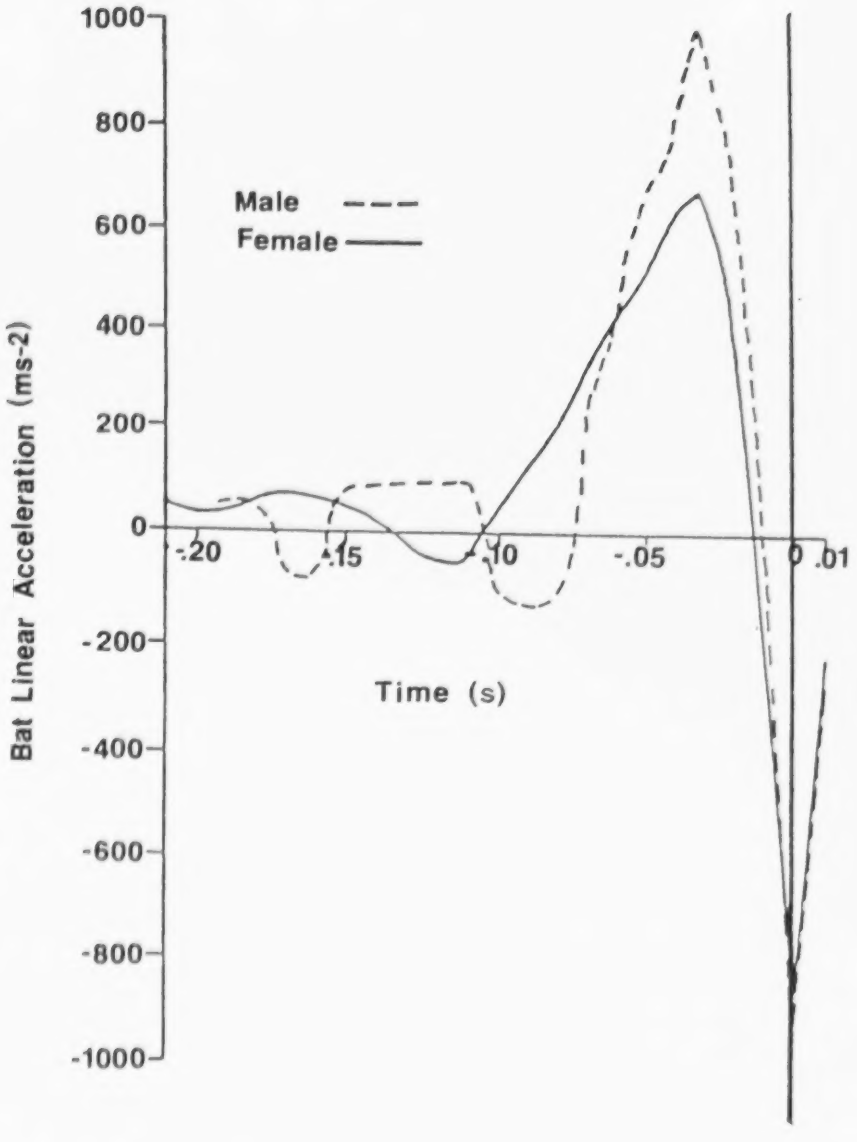

Figure 4. Bat Linear Acceleration

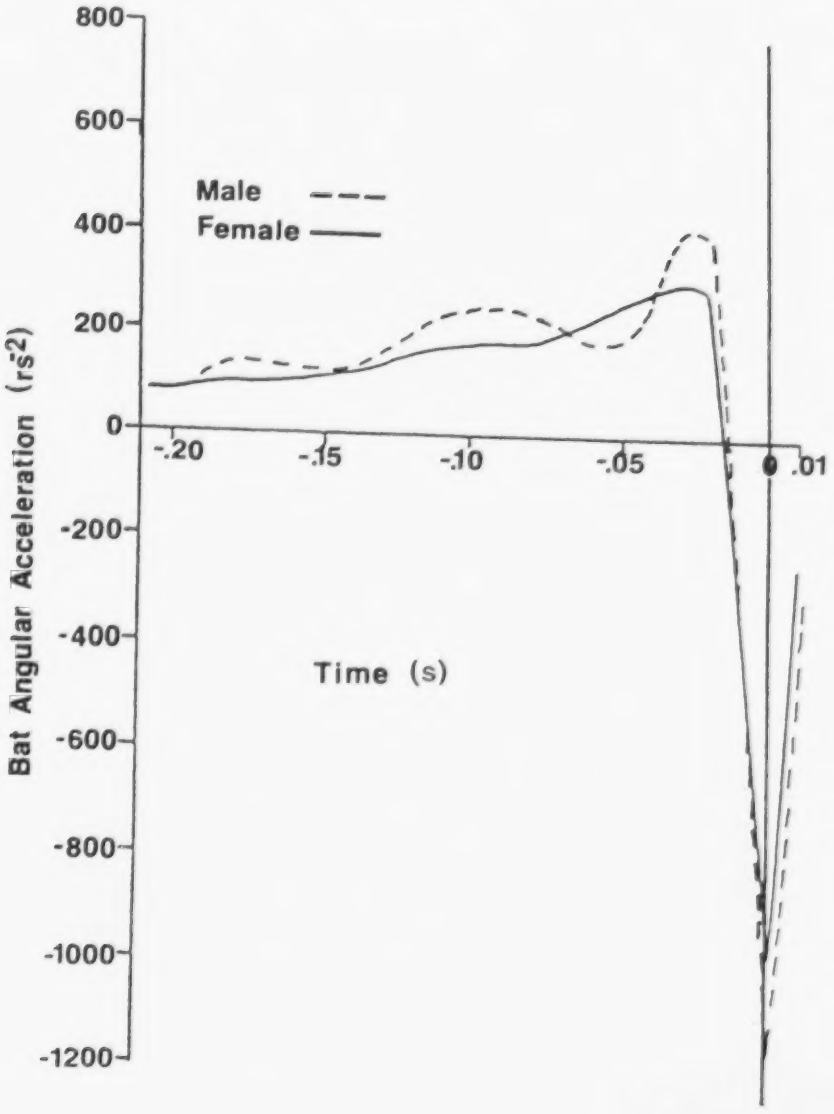

Figure 5. Bat Angular Acceleration